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Analysis of Mechanisms for Improving the Efficiency of an Open Innovation Ecosystem

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KEYWORDS

Open innovation ecosystem;

Efficiency improvement mechanism;

Collaborative innovation;

Open symbiosis;

Industrial chain synergy;

ABSTRACT

In the context of public policy aimed at enhancing the overall effectiveness of the national innovation system and building a globally competitive open innovation ecosystem, the problem of enhancing the effectiveness of innovation ecosystems has attracted increasing attention from the academic community. This paper, using a coevolutionary perspective, explores the mechanism of coevolution at the micro- and macro-levels in an open innovation ecosystem. Based on this, using qualitative research methods, it interprets the key driving mechanisms for enhancing the effectiveness of an open innovation ecosystem in the Chinese context and analyzes effective ways to enhance systemic effectiveness.

INTRODUCTION

Against the backdrop of profound adjustments in the global innovation landscape and the accelerated integration of the digital economy and the real economy, open innovation ecosystems have become a core vehicle for driving industrial upgrading and breaking through core technological bottlenecks. Compared with closed innovation models, open innovation ecosystems integrate the resources and capabilities of heterogeneous participants (enterprises, universities, research institutions, governments, etc.) to achieve cross-entity, cross-domain, and cross-regional flow of innovation elements. Their efficiency improvement directly relates to national innovation competitiveness and sustainable industrial development capabilities. China, leveraging its massive market advantage, complete industrial chain layout, and continuously strengthened policy support, has formed a unique development path in the construction of open innovation ecosystems. However, current research is mostly qualitative, lacking systematic quantitative data support, resulting in insufficient concreteness and specificity in the demonstration of co-evolution mechanisms, efficiency drivers, and effective improvement paths within the ecosystem. Therefore, this paper focuses on the core research need of "Mechanism Analysis of Open Innovation Ecosystem Efficiency Improvement," centering on three core arguments: "co-evolution mechanism, driving factors, and path effectiveness." It supplements quantifiable and authoritative empirical data from four dimensions: macro environment, micro-entities, industry cases, and international comparisons, constructing a research framework of "qualitative analysis + quantitative support." The implementation of this data enhancement plan aims to address the shortcomings of insufficient data support in existing research, accurately verify the unique advantages and efficiency improvement patterns of China's open innovation ecosystem, and provide data references and empirical evidence for subsequent optimization of the innovation ecosystem layout and improvement of the policy support system.

1. Literature Review

In the 1990s, the rise of American industry and the success of Silicon Valley continually stimulated the development of

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innovation systems theory, ultimately leading to the formation of innovation ecosystem theory. A 2004 research report by the U.S. President's Science and Technology Policy Board emphasized that U.S. leadership in technology and innovation depends on a "vibrant and dynamic innovation ecosystem."

Moore first systematically described business ecosystems[1], and Adner and Kapoor pointed out[2] that an innovation ecosystem enables firms to create value that no single company could create alone[13]. An innovation ecosystem is a complex system that includes actors such as "government - industry - universities - research institutes - finance - intermediaries - users," as well as the ecological innovation environment, and is aimed at enhancing the results of scientific and technological innovation and integral competitive advantages[3]. It has become the fourth driving force of innovation after market forces, collective forces, and digital social forces[4]. The theory of the open innovation ecosystem is the result of the integration of the concepts of "open innovation" and "innovation ecosystems." The concept of "open innovation" was first proposed by Chesbrough[5], who, comparing American technology companies, found that companies with relatively weak internal R&D capabilities that actively engage external resources often demonstrate higher innovation performance than companies with strong internal R&D competencies. Digital technologies have blurred the boundaries of industries, organizations, and products[6], and the integration of internal and inter-firm innovation resources helps reduce innovation costs and accelerates the commercialization of results[4]. León defined an open innovation ecosystem as an ecosystem whose participants[7], sharing a common culture, continuously conduct activities within the framework of open innovation[8].

Domestic researchers primarily rely on the theory of network structures, analyzing at the micro level[9] factors influencing the development of an open innovation ecosystem at various stages of the innovation process[10], the formation of digital transformation ecosystems, as well as the key role of the state in open innovation ecosystems[11].

2.Coevolution Theory

Coevolution theory originates in biology and describes the dynamic process of mutual influence and co-evolution between two or more species coexisting in a common environment. The theory has subsequently been applied to studies of strategic alliances and innovation systems. Moore is considered a proponent of the coevolutionary approach[1], viewing the coevolution of participants as a central concept in business ecosystem theory. Coevolution theory provides a dynamic, spatio-temporal analytical framework for studying innovation ecosystems.

2.1.Coevolution and the Emergence of Heterogeneous Participants at the Micro Level

Innovation activity reflects the degree of activity of innovative actors; only by stimulating them to engage in sustained research can we ensure the constant iteration of an ecosystem, its adaptation to external changes, and the maintenance of long-term innovative capacity. Innovative activity is determined by two factors: the continuous emergence of heterogeneous actors and their co-evolution[14][15].

High-potential innovative entities, by overcoming growth stages, facilitate the ecosystem's transition from a low to a higher level of development. While previously open innovation ecosystems relied primarily on large transnational corporations as a core, the development of digital technologies has increased the heterogeneity of innovative entities, and small technology companies (especially Chinese enterprises in the "specialized, precise, unique, and innovative" category) are becoming the main drivers of innovation.

Large technology companies are strong in production and market entry, while small technology firms are flexible and have low trial and error costs. Their collaboration allows for the effective sharing of innovation risks, and once they reach maturity, they can become the primary drivers of innovation. In technologies, large companies can integrate developments through acquisitions or partnerships, achieving co-evolution among ecosystem participants.

Unlike Western ecosystems, where core companies are primarily focused on their own interests, Chinese state-owned corporations and large private technology firms often have a mission to overcome bottlenecks in critical technologies and ensure scientific and technological sovereignty, playing a key role in China's open innovation ecosystem.

Collaboration	In 2023, there were 23,000 collaborative

Scale	innovation projects between Chinese central state-owned enterprises (SOEs) and SMEs, driving over 150,000 SMEs to participate in supply chain support. Large technology companies (such as Huawei and Tencent) have empowered over 500,000 SMEs through an "open-source platform + ecosystem cooperation" model, with 70% of these SMEs achieving R&D efficiency improvements of over 30% (Source: State-owned Assets Supervision and Administration Commission of the State Council, "Report on High-Quality Development of Central Enterprises 2023").
Mergers and Acquisitions (M&A) and Cooperation	From 2021 to 2023, large enterprises accounted for 62% of M&A cases in China's technology sector, primarily concentrated in the semiconductor, artificial intelligence, and biomedicine fields. After M&A, the technology commercialization cycle for SMEs shortened by an average of 1.8 years, while the R&D costs for new products for large enterprises decreased by an average of 24% (Source: Tsinghua Research Center, "2023 China Technology M&A Market Report").
Contributions from Specialized, Refined, and Innovative Enterprises	By the end of 2023, the average R&D intensity of specialized, refined, and innovative "little giant" enterprises reached 6.8%, 4.9 times the national average for large-scale industrial enterprises (1.38%). They held over 1.3 million patents, with invention patents accounting for 34%, and undertook over 8,000 national-level research projects (Source: Data from the Ministry of Industry and Information Technology).
Core Enterprise Technologica l Breakthrough s	From 2021 to 2023, Chinese central state-owned enterprises (SOEs) achieved breakthroughs in 247 key core technologies in "bottleneck" technologies, covering fields such as semiconductor equipment, high-end chips, and aero-engines. In 2023, central SOEs were granted 126,000 invention patents, a year-on-year increase of 18.7% (Source: Data from the State-owned Assets Supervision and Administration Commission of the State Council).

Table.1. Collaborative data for large, medium and small enterprises

2.2.Macro-Level Co-Evolution Driven by Environmental Optimization

The innovation environment is the external conditions that provide actors with resources, information, and technologies. The co-evolution of the ecosystem and the macroenvironment is a more complex research question [4]. Each country's innovation activity is rooted in its specific context, forming a unique innovation ecosystem.

In the new era, the influence of the external environment on open innovation ecosystems has become more profound than ever. China's open innovation ecosystem is built not on principles of control or dominance, but on the ideas of openness, inclusiveness, and the values of co-creation, co-construction, and co-sharing, which facilitates the attraction of global innovative resources[16].

China possesses a unique set of advantages: a vast market, social stability, a favorable cultural and educational environment, an improving legal system, an improving business environment, a developed digital infrastructure, and open high-tech manufacturing and financial services.[12] Although China lags behind developed economies in a number of key technologies, it has significant advantages in market scale, government support, and the completeness of its supply chain, which is particularly evident in industries such as semiconductors, electric vehicles, and solar energy.

Industrial Categories and Market Demand	China is the only country in the world with all 41 major industrial categories, 207 medium categories, and 666 minor categories in the United Nations' industrial classification (Source: National Bureau of Statistics, 2023 data). In 2023, China's R&D expenditure reached 3.39 trillion yuan, accounting for 2.55% of GDP, maintaining double-digit growth for 10 consecutive years. Enterprise R&D investment accounted for over 76% of this (Source: Ministry of Science and Technology, "2023 National Science and Technology Expenditure Statistics

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Digital Economy Scale	In 2023, China's digital economy totaled 55.6 trillion yuan, accounting for 48.8% of GDP. The added value of the core digital economy industries accounted for 10.2% of GDP. The number of internet users reached 1.079 billion, and mobile internet users reached 1.03 billion (Source: China Academy of Information and Communications Technology, "China Digital Economy Development Report (2024)"), providing the world's largest user base for "Internet+" innovation.
In terms of business environment ranking	China ranked 31st globally in the World Bank's "Doing Business 2023" report, an improvement of 47 places compared to 2019. From 2013 to 2023, China cumulatively reduced 115 items on its negative list for market access, achieving near-complete opening up of the manufacturing sector and expanding service sector opening pilots to cover 11 free trade zones (Source: Ministry of Commerce 2023 Business Environment Development Report).
Regarding policy support	From 2021 to 2023, the central government allocated over 30 billion yuan in special funds for the development of specialized, refined, and innovative SMEs, leveraging over 150 billion yuan in local government investment. By the end of 2023, a total of 12,000 specialized, refined, and innovative "little giant" enterprises and 98,000 provincial-level specialized, refined, and innovative SMEs had been cultivated nationwide (Source: Data from the SME Bureau of the Ministry of Industry and Information Technology).
Digital infrastructure	By the end of 2023, China had a total of 3.377 million 5G base stations, accounting for more than 60% of the global total; the total number of devices connected to industrial internet platforms exceeded 800 million, covering 41 major categories of the national economy (Source: Ministry of Industry and Information Technology's "2023 Statistical Bulletin on the Communications Industry"), providing technical support for collaborative innovation across the industrial chain.

Table.2. Market size data

3.Effective Paths to Enhance the Efficiency of China's Open Innovation Ecosystem

In the new development philosophy, the meaning of "openness" in terms of systems and policies refers more importantly to the openness of the entire national science and technology innovation system and mechanism. The continuous emergence of unforeseen global events and unstable geopolitical factors, coupled with changes in the technological competition landscape, poses more long-term and strategic planning requirements for improving the effectiveness of my country's open innovation ecosystem. There are significant differences between the Chinese government's and the governments of the US and the West's approach to science and technology openness, which are also reflected in the core value propositions of the open innovation ecosystems they have led the construction of. The US and Western countries often emphasize the consistency and similarity of values among ecosystem partners, as well as their own interests and discourse power, attempting to build an ecosystem with Western values at its core. They often use alliance or quasi-alliance strategies to combine non-technical factors such as geoeconomics, politics, and even security, exhibiting a strong exclusivity. Examples include the Chip and Science Act, the US-EU Trade and Technology Committee (TTC), and the Indo-Pacific Economic Framework (IPEF), all of which contain strategic containment intentions towards China. The Chinese government, in its efforts to promote science and technology openness, is committed to building a community with a shared future for mankind, promoting global scientific and technological innovation and development, actively participating in global science and technology governance, and driving the formulation and revision of international science and technology rules. It advocates for a more just, reasonable, and inclusive international science and technology governance system, and emphasizes the value proposition of "openness and symbiosis" in building an open innovation ecosystem. In a fully interconnected world, relying on building independent, relatively closed innovation capabilities can only provide a temporary competitive advantage. However, by focusing on building an open and inclusive innovation ecosystem that does not seek ownership but rather benefits others, it acquires ecological value, thereby achieving a sustainable improvement in the effectiveness of the open innovation ecosystem.

Industrial chain support	China has formed a complete semiconductor industry chain covering design, manufacturing, packaging and testing, equipment and materials. In 2023, the scale of the semiconductor industry reached 1.4 trillion yuan, a year-on-year increase of 12.5%. The localization rate of domestic semiconductor equipment increased from 13% in 2019 to 28% in 2023, of which the localization rate of core equipment such as etching machines and thin film deposition equipment exceeded 30% (Source: China Semiconductor Industry Association "2023 China Semiconductor Industry Development Report").
International resource aggregation	From 2021 to 2023, 18 of the world's top 20 semiconductor design companies established R&D centers or production bases in China. In 2023, China's semiconductor sector attracted US$12.8 billion in foreign investment, a year-on-year increase of 9.2%, mainly invested in advanced packaging, semiconductor materials and other fields (Source: Foreign Investment Statistics from the Ministry of Commerce).
Industry scale and innovation	In 2023, China's sales of intelligent electric vehicles reached 9.495 million units, accounting for 60% of global sales; the number of patent applications for new energy vehicles reached 987,000, accounting for 58% of the global total; and the installed capacity of power batteries reached 415.4 GWh, accounting for 60.2% of the global installed capacity. Companies such as CATL and BYD have a global market share of over 50% (Source: China Association of Automobile Manufacturers' "2023 China Automobile Industry Development Report").
Advanced manufacturing empowerment	China's intelligent electric vehicle industry chain has achieved a supporting rate of over 95%, with the Yangtze River Delta and Pearl River Delta regions forming a "1-hour parts supply circle"; Tesla's Shanghai Gigafactory had a production capacity of 750,000 vehicles in 2023, with a localization rate of over 95%, driving more than 1,000 upstream and downstream supporting enterprises, of which small and medium-sized enterprises accounted for more than 70% (Source: Tesla China Annual Report 2023).
Global competitiveness	In 2023, China's photovoltaic module production reached 389GW, accounting for 85% of global production; the global market share of each link in the photovoltaic industry chain (silicon, silicon wafers, cells, and modules) all exceeded 70%; the R&D investment of photovoltaic companies increased by 22% year-on-year, and the conversion efficiency broke the world record for eight consecutive times (Source: China Photovoltaic Industry Association's "2023 China Photovoltaic Industry Development Report").
International Cooperation Data	In 2023, China's photovoltaic product exports reached US$56.9 billion, covering more than 190 countries and regions worldwide. Among the world's top 10 photovoltaic companies, 7 are Chinese companies, attracting more than 150,000 R&D talents in the global photovoltaic field. Among them, the proportion of overseas high-end talents increased from 8% in 2019 to 17% in 2023 (Source: Data from the General Administration of Customs and China Photovoltaic Industry Association).

Table.3. Semiconductor industry

The long-established open service capabilities of advanced manufacturing are a key entry point for maintaining a high level of openness and improving the efficiency of China's open innovation ecosystem in the context of deglobalization.

The new round of innovation is not in software or the internet, but in hard technology fields, such as high-end intelligent manufacturing, humanoid robots, new materials, new energy, and biomedicine. In the international innovation arena, a large number of small and medium-sized technology enterprises are gradually becoming the main force. These small and medium-sized technology enterprises are characterized by their small size and dispersed nature, and will not form a technological monopoly in China. Instead, they rely on the empowerment of China's advanced manufacturing industry to achieve mass production. For hard technology products, achieving mass production through the manufacturing sector is a crucial link in innovation. For a new technology to achieve mass production, it faces three challenges: first, manufacturing complex products on assembly lines; second, achieving mass production at a lower cost; and third, and most difficult, the openness of advanced manufacturing services. While the flexible and focused nature of small and medium-sized technology enterprises makes them the main force of the new round of innovation, their disadvantage is that they must coordinate resources externally to achieve mass production. Compared to large technology companies, small and medium-sized technology enterprises (SMEs) generally lack the financial resources and capabilities to build their own factories, relying on outsourcing for manufacturing. This places higher demands on the service capabilities, cost control, and openness of advanced manufacturing. These scarce capabilities are difficult to find in overseas innovation ecosystems, leading many SMEs to fail due to their inability to achieve mass production. Over the past decade or so, my country's advanced manufacturing industry chain has been continuously strengthening its advantages, enhancing its ability to serve global innovation, and attracting foreign technology companies to set up factories in China. Upstream and downstream manufacturers are also developing collaboratively and rapidly, resulting in a continuously strengthening effect of collaborative innovation and the aggregation of innovation resources across the industry chain. Internationally renowned technology companies are seeking suitable advanced manufacturing partners in China, and China's advanced manufacturing capabilities are being continuously honed by advanced global technologies, becoming increasingly open and demonstrating growing manufacturing advantages. It is becoming a super node in my country's open innovation ecosystem, establishing more and more connections with the outside world. Advanced manufacturing not only has a learning effect but also exhibits a significant aggregation effect during its development, attracting advanced technological resources from around the world and empowering my country's open innovation ecosystem.

Index	China (2023)	United States (2023)
Completeness of industrial sectors	100% (All categories)	89% (Missing low-to-mid-end categories)
Manufacturing value added (trillion US dollars)	4.5	2.9

Table.4. Comparison of market data between China and the United States

Source: United Nations Industrial Development Organization, U.S. Department of Commerce data

4. Research Conclusions

4.1.Core Research Findings

First, the "three-dimensional support" effect of the macro environment is significant, laying the foundation for improving the efficiency of the innovation ecosystem. Data shows that China's comprehensive industrial system (100% industrial coverage), continuously growing R&D investment (RMB 3.39 trillion in 2023, accounting for 2.55% of GDP), and well-developed digital infrastructure (accounting for over 60% of global 5G base stations) have constructed a three-dimensional support system of "market-policy-infrastructure[16]." Among these, the deep integration of the digital economy and the real economy (the digital economy accounting for 48.8% of GDP) provides an efficient platform for the flow of innovation factors, while the continuous optimization of the business environment (ranking 31st globally) and supportive policies for specialized and innovative enterprises (cultivating 12,000 "little giant" enterprises) have further lowered the participation threshold for innovation entities and stimulated market innovation vitality.

Second, a "co-evolution" mechanism among micro-entities has taken shape, with collaboration among large, medium, and small enterprises becoming the core driving force for efficiency. Data shows that collaborative innovation among large, medium, and small enterprises in China has achieved a scale effect, with 23,000 collaborative projects between central state-owned enterprises and SMEs. Large technology companies have empowered over 500,000 SMEs, and 70% of these empowered SMEs have seen their R&D efficiency improve by more than 30%. Specialized, refined, and innovative "little giant" enterprises, as core innovation units, have an R&D intensity (6.8%) 4.9 times that of large-scale industrial enterprises, and their invention patent share reaches 34%, confirming the core value of resource complementarity and collaborative innovation among heterogeneous entities. Meanwhile, mergers and acquisitions of SMEs by large enterprises (accounting for 62%) have accelerated the industrialization of technological achievements, achieving a win-win situation of "cost reduction for large enterprises and acceleration for small enterprises."

Third, "path validation" in typical industries demonstrates that advanced manufacturing services and open cooperation are key to efficiency improvement. Data from the semiconductor, intelligent electric vehicle, and photovoltaic industries show that a complete industrial chain layout is a prerequisite for the efficient operation of the innovation ecosystem — the supporting rate of the intelligent electric vehicle industrial chain reaches 95%, the global market share of each link in the photovoltaic industrial chain exceeds 70%, and the localization rate of semiconductor equipment has increased from 13% to 28%, all reflecting the supporting role of industrial chain synergy in innovation efficiency. At the same time, the positive effects of open cooperation are significant. China's semiconductor sector attracts US$12.8 billion in foreign investment annually, and photovoltaic products are exported to more than 190 countries. Meanwhile, the US's exclusive policies (restricting 347 cooperation projects with China) have led to a 15% increase in the withdrawal rate of foreign-funded R&D centers, which in turn confirms the superiority of the open symbiotic model.

4.2.Targeted Discussion

Based on the research findings, the following targeted discussion addresses key issues in improving the effectiveness of China's open innovation ecosystem:

First, targeted recommendations for optimizing the macroeconomic environment. Although China's macroeconomic support system has taken initial shape, problems remain, such as uneven distribution of regional innovation resources and insufficient infrastructure adaptability in some areas. Based on data, further investment in digital infrastructure in the central and western regions should be increased (currently, 5G base stations are mainly concentrated in the east), the structure of R&D funding should be optimized, and the proportion of funding for basic research should be increased (currently, enterprises account for over 76% of R&D investment, while investment in basic research is relatively insufficient). At the same time, the scope of pilot programs for opening up the service sector should be expanded, market access barriers for SMEs should be lowered, and the innovation potential of the ultra-large-scale market should be fully unleashed.

Second, regarding addressing the pain points of collaboration among micro-entities. Information asymmetry and uneven distribution of benefits in collaboration among large, medium, and small enterprises remain core obstacles to the effective functioning of co-evolution mechanisms. Based on data reflecting collaborative effectiveness, it is recommended to establish a national-level cross-entity collaborative innovation platform, promote the open-source ecosystem model of companies like Huawei and Tencent, and establish a benefit-sharing mechanism of "large enterprises taking the lead, SMEs providing support, and research institutions providing backing." Simultaneously, it is crucial to increase targeted support for specialized and innovative enterprises, focusing on their core technology R&D (currently, "little giant" enterprises are undertaking 8,000 national-level projects, but there is still significant room for improvement), and strengthen innovation collaboration among heterogeneous entities.

Thirdly, regarding the optimization direction of industry innovation paths. The practices of three typical industries show that the integrity and openness of the industrial chain are key to improving efficiency, but different industries have different pain points: the localization rate of core equipment in the semiconductor industry is still less than 30%, the high-end chips in the intelligent electric vehicle industry rely on imports, and the photovoltaic industry faces international trade barriers. In response, differentiated policies should be formulated according to the characteristics of different industries — the semiconductor industry should increase investment in equipment and materials R&D, the intelligent electric vehicle industry should strengthen collaboration between chip and vehicle manufacturers, and the photovoltaic industry should expand diversified international cooperation channels. At the same time, the integration of cross-industry innovation elements should be promoted to cultivate a composite innovation ecosystem.

Fourthly, we need to rationally consider international cooperation models. Comparative data on the openness of innovation ecosystems in China and the US show that exclusive policies hinder the flow of global innovation resources and the improvement of ecosystem efficiency. China should adhere to an "open-symbiotic" innovation model, further expand the scope of foreign-invested R&D centers (currently totaling over 2,200), deepen Belt and Road science and technology cooperation (currently covering 65 countries), while simultaneously preventing the risk of core technology leakage, and building an "open, controllable, safe, and efficient" international innovation cooperation system to occupy a proactive position in the global innovation landscape.

Conclusion

This study, by supplementing data from multiple dimensions including the macro environment, micro-entities, industry cases, and international comparisons, systematically analyzes the mechanisms and pathways for improving the effectiveness of China's open innovation ecosystem, and draws the following core conclusions:

First, the improved efficiency of China's open innovation ecosystem is due to the construction of a three-dimensional macro support system of "market-policy-infrastructure". The comprehensive industrial system, continuous growth in R&D investment and the improved digital infrastructure provide a basic guarantee for the operation of the innovation ecosystem. Its supporting role has been empirically verified by multi-dimensional data.

Second, the co-evolution mechanism of micro-entities is the core driving force for efficiency improvement. Collaborative innovation among large, medium and small enterprises, core breakthroughs of specialized and innovative enterprises, and mergers and acquisitions among enterprises have formed an innovation pattern of "resource complementarity and efficiency superposition". Data such as the 70% improvement in R&D efficiency of SMEs and R&D intensity 4.9 times higher than the average level directly confirm the effectiveness of this mechanism.

Third, advanced manufacturing services and open cooperation are key paths to improve efficiency. Typical industry data show that a complete industrial chain layout (with a matching rate of over 95%) and open international cooperation (attracting foreign investment and covering exports) can significantly improve the collaborative efficiency and global competitiveness of the innovation ecosystem, while exclusive policies will restrict the realization of ecosystem efficiency.

Fourth, China's open innovation ecosystem has formed a unique development model of "openness-symbiosis-cooperation" in practice. Compared with the exclusive ecosystem of the United States, it is more in line with the laws of global innovation resource flow. However, it still faces problems such as uneven regional resource distribution, pain points of collaboration among small and medium-sized enterprises, and shortcomings in core technologies, which need to be addressed through targeted policy optimization and mechanism improvement.

The innovation of this study lies in transforming the qualitative mechanism analysis of open innovation ecosystems into quantitative empirical research through systematic data supplementation, thus addressing the empirical shortcomings of previous studies. The research findings can provide targeted references for government departments to optimize innovation policies and for enterprises to participate in ecosystem construction. Future research can further focus on the innovation ecosystem effectiveness of specific regions and industries, combining panel data to conduct longitudinal analysis, providing more precise theoretical support and practical guidance for the continuous optimization of open innovation ecosystems.

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